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THESIS

ANALYSIS AND COMPARISON OF DODAF AND ZACHMAN FRAMEWORK FOR USE AS THE ARCHITECTURE FOR THE UNITED STATES COAST GUARD'S MARITIME PATROL COASTAL (WPC)

by

Latan K. Griffin

September 2005

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13. ABSTRACT (maximum 200 words)

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- USD (A&T), ASD (C3I), JS/J6 Memorandum
Subject: DoD Architecture Coordination
Council (ACC), 14 January 1997

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This thesis proposes to compare two different architectural frameworks for use by the WPC's SADD: 1) DoD Architecture Framework and 2) Zachman Architecture Framework.   The thesis will compare and recommend the architectural framework that will at most enhance the mission statement set forth by the Original Requirements Document (ORD) of the WPC.

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ANALYSIS AND COMPARISON OF DODAF AND ZACHMAN FRAMEWORK FOR USE AS THE ARCHITECTURE FOR THE UNITED STATES COAST GUARD'S MARITIME PATROL COSTAL (WPC)

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ABSTRACT

"The Defense Science Board and other major studies have concluded that one of the key means for ensuring interoperable and cost effective military systems is to establish comprehensive architectural guidance for all of DoD."

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EXECUTIVE SUMMARY

In the mid 1990s, the United States Coast Guard commissioned a study to analyze their existing assets, capabilities, future needs and acquisition strategy. It was determined that the USCG mission needs exceeded the capabilities of their existing assets. Moreover, the USCG had been replacing acquiring platforms on a need basis – when one asset wore out, the service acquire an asset to replace it – a one-to-one swap. The commission quickly surmised that that practice was slowly relegating the USCG to an inferior role in its position of homeland protection. They reported that unless a major acquisition was sought, the USCG would not have the assets and platforms to accomplish its major missions.

An Integrated Deepwater System (IDS), headed by Northrop Grumman and Lockheed Martin Corporations, was incorporated to assist in the USCG acquisition strategy. The USCG and the IDS determined that three classes of cutters would need to be built and they are: 1) the WMSL – large cutter, 2) the WMSM – the medium sized cutter and 3) the WPC – patrol cutter. The WMSL and WMSM will have soft-kill capabilities, be able to be fully interoperable with the United States Navy command and be able to deploy for long periods of time. The WPC is a smaller craft that is used for interdiction purposes and law enforcement. It is able to deploy 5 days as opposed to the 230 day deployment of both the WMSL and WMSM.

Based on mission need, capabilities, relevance and required performance of the WPC, this thesis compares two architecture frameworks: the DoD Architecture Framework and Zachman Framework for use as the primary architecture for developing its System Architecture Description Document (SADD).

A study of the DoDAF and Zachman framework included purpose, history and capabilities of the documents. The methodologies for research included initial expectations, pros and cons of the two documents, comparison of the frameworks and developing a survey.

After polling sixty-seven directors, managers and supervisors (of which eighteen responded) and analyzing their responses, it was determined that the DoDAF is the architecture framework of choice for men and women that work in the defense industry.

After comparing the frameworks, analyzing the mission needs of the WPC and determining that the USCG and U.S. Navy leaders are determined to make their services interoperable and interconnected, this thesis recommended the DoDAF be the framework used to develop the WPC's SADD.

Several flaws were identified within the DoDAF and recommendations were made to overcome them and some modifications were recommended to enhance the viability of the framework.

This thesis recommends that future studies be conducted to combine the DoD business frameworks with the DoDAF to capture the business aspects of enterprise development.

I.   INTRODUCTION

A.   BACKGROUND

The United States Coast Guard (USCG) has been protecting the property and lives of Americans since their incorporation in 1790. Then as now, the agency used the best products available to them to accomplish their mission. Due to an increase in drug patrolling, war fighting, and interdiction related activities during the last two decades the USCG has started to experience a growth in their deepwater responsibilities. The USCG has many different roles varying from Maritime Law Enforcement, Maritime Safety, National Defense, and Marine Environmental Protection. All of the roles stated are performed in the deepwater arena and this has put a strain on the USCG's aging resources.

In the mid 1990's the USCG commissioned a mission analysis to be done to access their needs and a Deepwater Mission Analysis Report was submitted to the Chief of the Office of Law Enforcement and Defense Operation on November 6, 1995.[1] This report contained a summary of each role (as stated above) and each role's mission, current asset capabilities to meet each mission, mission performance, and future demands to accomplish missions. The report was quite extensive in its projections that the USCG's ability to continue to conduct its overall mission was limited by its aging resources which were/are rapidly approaching the end of their service lives.

In the past the USCG procured ships, helicopters and other resources as they became obsolete or insupportable on a platform class by platform class basis, on a one-to-one basis.[2] This approach limited the agency's ability to keep up with technological advances, avoided long range re-acquisition planning, wasted money by not having an acquisition plan, and did not consider overall integrated asset capabilities. The old acquisition approach used by the USCG has tended to leave the agency over-utilized without the resources to completely fulfill its roles. Growing maintenance requirements place greater demands on the logistics infrastructure already stretched too thin and asset operational availability continues to decrease as cutters and aircraft spend more time at

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the pier and in the hangar. Older maintenance needy and technologically archaic assets require larger and necessarily more expensive crews.[3]

To continue to meet America's 21st century maritime threats and challenges, the Coast Guard initiated the Integrated Deepwater System (IDS) program, the largest and most innovative acquisition program in USCG history.[4] The IDS is a long-term project with full implementation scheduled for 2022. In that time the IDS will have upgraded some existing assets and made the transition to new, more capable platforms with systems that have greater command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) and innovative logistics support. The USCG is teaming with the Navy to support the National Fleet Policy to ensure that all IDS platforms and systems are interoperable, non-redundant and absolutely compatible to attend to the Nation's maritime security and defense needs.[5]

The purpose of the IDS is to concentrate on system-wide capabilities and not assets as the old acquisition strategy did. The IDS is a joint effort between Northrop Grumman Corporation and Lockheed Martin: A partnership formed to be a system integrator and to serve as the USCG's service partner. The IDS will analyze existing assets and then upgrade or retire assets, while introducing new assets in the form of cutters and aircraft.

Northrop Grumman Corporation is tasked with building or overseeing the construction of three classes of cutters for the USCG: The Maritime Security Cutter, Large (WMSL), Maritime Security Cutter, Medium (WMSM) and Maritime Patrol Coastal (WPC).

The WMSL is 415 foot in length, displacement of 4,300 long tons (LT), range of 12, 000 nautical miles (NM), sustained speed of 28 knots and provisional endurance of 60 days. During times of war the WMSL will come under direct Navy command and is designed to deploy 230 days per year. This cutter has soft-kill capabilities and deploys with two aircraft.

The WMSM is 350 foot in length, displacement of 2,921 LT, has a range of 9,000 NM, sustained speed of 26.5 knots and provisional endurance of 45 days. During times of war the WMSM will come under direct Navy command and is designed to deploy 230

days per year. This cutter also has soft-kill capabilities and deploys with two aircraft.

The WPC is 140 foot in length, a displacement of 200 LT, a range of (less than) 5000 NM, sustained speed of 30 knots and provisional endurance of 5 days. This cutter can be deployed independently in support of law enforcement, port security, search and rescue, and defense operations missions. Typical missions include near-shore fisheries, choke point interdiction, barrier patrols, and providing a show of presence in areas of concern.[6]

The WPC mission and capabilities differ in large part from the WMSL and WMSM and therefore it is possible that its system of system's architecture document can deviate from the architecture document of the larger cutters, which is based upon the Department of Defense Architecture Framework (DoDAF), which has at its heart the C4ISR system.

B.   PURPOSE

The purpose of this thesis is to determine which of two architecture frameworks – the DoDAF or the Zachman should be used to develop the System of Systems Architecture Document (SADD) for the USCG's WPC. The criteria for selection of an architecture framework will be based on WPC's mission need, capability, entrance and exit criteria, alternatives, relevance and performance as stated by the USCG in their initial requirements documentation. This research will evaluate the above named criteria using a system architecture approach. The objective is to determine the advantages and disadvantages of each framework in relation to mission needs of the WPC. Research will analyze each architecture framework in relation to the mission of WPC. Research will also analyze standard operating methods of each framework. A comparison of each architecture framework will be discussed to examine similarities and differences and their application to WPC.

C.   RESEARCH QUESTIONS

The following questions will be addressed within this paper:

1.   What is an architecture framework?

2.   Why is an architecture framework needed for a DoD project?

3.   When will an architecture framework be used?

4.   What is the history of architecture frameworks in DoD projects?

5. How does an architecture framework assist in the development of a DoD project?

6. What are the various types of architecture frameworks?

7. What are the advantages and disadvantages of the Zachman framework?

8. What are the best and worst functions of the Zachman framework?

9. What are the advantages and disadvantages of the DoDAF?

10. What are the best and worst functions of DoDAF?

11. Based on mission need, which of the two architecture frameworks should be used by the WPC's IPT?

12. How effective can an architecture framework be in the development of a DoD project?

D.   BENEFITS OF STUDY

This study will provide a systems-based analysis of two architecture frameworks to aid in selection of one framework to be used as the principle framework in forming the WPC's System Architecture Description Document (SADD). The recommendations of this study can be applied to any DoD acquisition project.

E.   SCOPE AND METHODOLOGY

1.   Scope

This thesis will be limited to the study of the USCG Deepwater acquisition project of one class of cutters that is projected to have a littoral mission and limited capabilities; the other two classes of USCG cutters will have a deepwater, naval-type mission and greater capabilities. A recommendation to use one type of architecture framework for development will be part of this study.

2.   Methodology

The methodology used in this thesis research consists of the following steps:

Review government publications that describe the Department of Defense Architecture Framework and its use in project development.

Conduct a literature review of books, magazine articles, and other library information resources on the Department of Defense Architecture Framework and Zachman Architecture Framework.

Conduct a thorough review of previous research on history, comparison and use of Architecture Frameworks in DoD projects.

Conduct a review of current capabilities of the Department of Defense Architecture Framework and compare it to the Zachman Architecture Framework.

Create a demonstration of the use of an architectural framework on a DoD project.

Create a survey to gather feedback from Technical Directors, Program Managers, and supervisors about the use of architecture frameworks in DoD projects.

Analyze survey feedback and make recommendations to improve selection of architectural frameworks.

Establish a means for future feedback methods involving selection of architectural frameworks.

F.   ORGANIZATION OF STUDY

This thesis begins with an introduction that briefly states the background, the purpose, and benefits of the study and gives an idea of its nature by means of a listing of the research questions that have been explored. The next chapter delves into the two architecture frameworks, their purpose, history and capabilities. The third chapter deals with the initial expectations, pros and cons of the two architecture frameworks. This chapter also presents a comparison of the two architecture frameworks and talks of the survey and its development. The fourth chapter analyzes the results from the survey and presents conclusions about architecture framework usage in the DoD workplace. The fifth chapter describes implementation of an architecture framework for the System Architecture Description Document of the WPC. It also analyses the flaws of an architecture framework and makes recommendations for modifications to the architecture framework. Conclusions, recommendations and areas for further study make up the final chapter.

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II.   LITERATURE REVIEW

A.   INTRODUCTION

A wealth of information on architecture frameworks and their application can be found on the internet and in many books. The bulk of the research conducted for this thesis came from sources found on the worldwide web, NPS library and some books.

The aim of this thesis is to compare two frameworks (DoDAF and Zachman) for usage as the primary architecture framework for the Systems of Systems document of the USCG's WPC. One question that will be answered in this thesis is "what is an 'Enterprise Architecture Framework'." ***Enterprise*** is defined as 'a project or undertaking that is especially difficult, complicated, or risky'. ***Architecture*** is defined as 'the art or science of building'. ***Framework*** is defined as 'a basic conceptional structure (as of ideas)'.

When one thinks of architecture, buildings and the plans to accomplish their construction come to mind. From the smallest house to the tallest building in the world, all must have plans and frameworks to accomplish their erection. One would never think of trying to build a magnificent skyscraper without detail plans and engineering efforts. From the pyramids of ancient Egypt to the Sears Tower in Chicago, massive efforts have been spent to ensure that the conceptional structure will be assembled in a satisfactory manner. Many questions have to be answered before ground-breaking. What purpose will the building serve? Who will occupy the building and what function will they serve? Where will the building be located and will that location serve the purpose of the users? Why is this building needed? What kind of forces will this building have to withstand? What kind of materials will the building be made of? What finishes are needed? How long will the building be functional? When should the building be built and how long will it take to build? As one can see, many questions have to be addressed and many detailed plans must be drawn up to facilitate the construction of a building.

In today's society, because of the size of the populous that must be served, massive and complex projects have been undertaken – both physical and informational. Because of the complex and interrelated nature of our economy and various other entities

such as our defense forces, we must ensure that all of our capabilities are established and recognized and that future growth can be sustained. To successfully complete these efforts, the United States government and major companies alike, have developed and employed the use of ***enterprise architecture frameworks*** which can be described as a comprehensive framework, a set of operational guideline and rules to follow to manage and align an organization's operations and projects with their overall strategy. It consists of two subsets: Those that are considered as basic (compulsory) and those which are optional and may add value or efficiency in a given application. The architecture framework should be able to be modified to add value in future applications based on organizational growth and needs.

An enterprise architecture framework should be a structured process that helps guide an organization to make sound, targeted decisions about how to manage its information-related assets for maximum effectiveness. Implementing enterprise architecture generally starts with documenting the organization's strategy and other necessary details such as where and how it operates. The process then cascades down to documenting discrete core competencies, business processes, and how the organization interacts with itself and with external parties such as customers, suppliers, and other entities.[7] An organization should be able to use an enterprise architecture framework to break a major, complex undertaking into many manageable bite-sized pieces, employ a methodology (or science) as an effort for accomplishment, and blend those efforts into a conceptional structure for development.

B. DEPARTMENT OF DEFENSE ARCHITECTURE FRAMEWORK (DODAF)

The DoDAF is an enterprise architecture framework develop by the Department of Defense (DoD) C4ISR (Command, Control, Communications, Intelligence, Surveillance, and Reconnaissance) Architecture Working Group (AWG) to provide guidance for describing architectures.

1. Purpose of DoDAF

The DoDAF is intended to ensure that architectures developed by the Commands, Services, and Defense Agencies are interrelatable between and among the organizations' operational, systems, and technical architecture views, and are comparable and

integratable across Joint and multi-national organizational boundaries. The framework is intended to ensure that a clear audit trail exists from mission operations and effectiveness measures to the characteristics of current and postulated C4ISR systems and their contributions (performance and interoperability metrics) to mission operations.[8] The DoDAF will provide guidance for describing architectures for both warfighting operations and business operations and processes. It will provide the guidance, rules, and product descriptions for developing and presenting architecture descriptions that ensure a common denominator for understanding, comparing, and integrating Families of Systems (FOS), Systems of Systems (SOS), and interoperating and interacting architectures.[9] The extended purpose of the DoDAF is to meet DoD policy as stated by John P. Stenbit, Department of Defense Chief Information Officer, in his February 9, 2004 memorandum authorizing the immediate use of DoDAF Version 1.0 , 'Through several DoD Directives and related issuances, the DoD has established policy and procedures that direct the use of integrated architectures to support Capital Planning and Investment, Joint Capabilities Integration and Capabilities System (JCIDS), the Acquisition System, and interoperability between and among information technology (IT) and National Security Systems (NSS). In addition, the Information Technology Management Reform Act (ITMRA)/Clinger Cohen Act (CCA) of 1996 mandates that the Chief Information Officer (CIO) of each Executive Agency is responsible for "developing, maintaining, and facilitating the implementation of a sound and integrated information technology for the executive agency."[10]

2. History of DoDAF

Historically, Commands, Services and Agencies in DoD have instituted architectures, definitions, techniques and presentation schemes to suit their individual needs in deference to other agencies. However, as technology advanced and DoD became increasingly aware of a need to synthesize on the joint and multinational battle theater as spurred by Desert Storm and other major conflicts, DoD sought a way to standardize architectures.

In October 1995, the Deputy Secretary of Defense directed that a DoD-wide effort be undertaken to define and develop better means and processes for ensuring that Command, Control, Communications, Computers and Intelligence capabilities meet the

needs of the warfighter. In response to that direction, a C4ISR Integration Task Force (ITF) was established under the direction of the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (ASD [C3I]). The C4ISR Architecture Framework, Version 1.0, dated 7 June 1996, was developed as a product of the Integrated Architectures Panel (IAP), one of several panels established by the ITF.

In October 1996, the ASD (C3I) and Joint Staff/J6 established the C4ISR Architecture Working Group to continue the effort begun by the IAP. The effort resulted in the publication of the C4ISR Architecture Framework; Version 2.0 dated 18 December 1997. The utility of the C4ISR Architecture Framework, combined with both Federal and DoD policy encouraging the use of architectures, led DoD to evolve the document into the DoDAF in 2003.[11] This evolution was accomplished under the direction of the Architecture Framework Working Group (AFWG) which was composed of Joint Staff, Military Services, and various other DoD agencies representatives.

The most powerful tool used by the legislative and executive branches of the United States government to enact information technology reform was the Clinger-Cohen Act (CCA). In 1996, recognizing the importance of information technology for effective government, the Information Technology Management Reform Act (ITMRA) and the Federal Acquisition Reform Act were signed. The acts became known as the (CCA) and they focused on the need for Federal Agencies to improve the way they select and manage information technology (IT) resources. The CCA states "information technology architecture, with respect to an executive agency, means an integrated framework for evolving or maintaining existing information technology and acquiring new information technology to achieve the agency's strategic goals and information resources management goals". The DoDAF grew out of this and related policies that identified the need for a unified architecture framework to be applied during the development of those architecture descriptions dictated by policy.[12]

3.   **Capabilities of DoDAF**

The Department of Defense has mandated that all military service branches use the DoDAF for large-scale software-intensive systems. This framework is partitioned into two volumes and a deskbook:

- Volume I provides definitions, guidelines, and related background material.

- Volume II contains descriptions for each product

- The DoDAF Deskbook provides supplementary information to framework users.

The framework provides guidance, rules, and product descriptions for developing and presenting architecture descriptions. An architecture description is a representation of a defined domain, as of a current or future point in time, in terms of its component parts, what those parts do, how the parts relate to each other, and the rules and constraints under which the parts function. It will also describe how the architecture for a system or system of systems (SoS) should be documented.

In the framework, there are three major perspectives that logically combine to describe an architecture description and each view depicts certain architecture attributes. They are Operational View (OV), System View (SV), and Technical View (TV). Each of the three views depicts certain architecture attributes. Some attributes bridge two views and provide integrity, coherence, and consistency to architecture descriptions.[13] The operational view (OV) consists of 9 products; the system view (SV) consists of 13 products; and the technical view (TV) consists of 2 products. An additional all view (AV) consists of two products, one of which is a graphic showing the weapons platforms involved, and the other is a data dictionary containing the data items defined in the OV, SV, and TV products.[14]

Architecture products are those graphical, textual, and tabular items that are developed in the course of building a given architecture description and that describe characteristics pertinent to the purpose of the architecture. When used as a part of an architecture description, all products, even those whose primary presentation is graphical, should contain explanatory text.[15] Individual products are not stand-alone entities but represent depictions of subsets of architecture data describing various aspects of architecture. Therefore, relationships exist among the architecture data elements that compose the various products, creating relationships among the products. Figure 2 illustrates some of the major relationships among selected products.[16] A list of all the

products is contained in Table 1 in Appendix A. An in-depth description of each product and the relationships among products are discussed in detail in Volume II of the DoDAF.
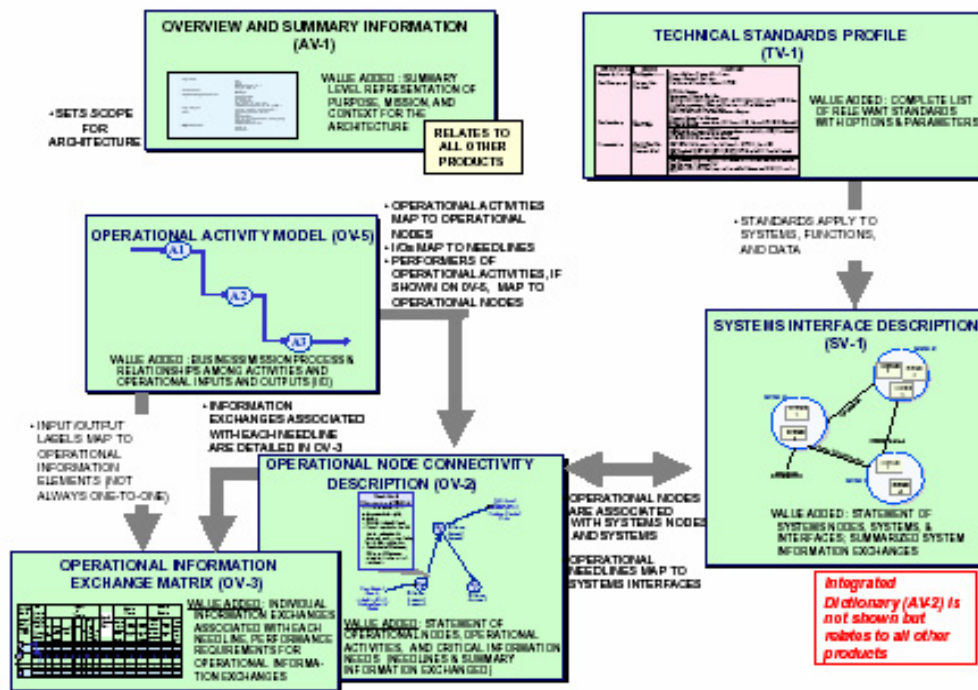
Figure 1.   Relationships among products

The OV describes the activities, operational elements, and information flows required for a number of missions supported by the SoS. This information is described in terms of the mission's nodes, the operational activities conducted within these nodes, and the needlines connecting the internodal activities. A node often means a mobile weapons platform (e.g., a ship, tank, or aircraft) or a fixed ground platform (e.g., a command and control center, or a communication hub). An operational activity is usually associated with a warfighter and consists of a combination of manual and automated actions taken by the warfighter, such as tactical planning and engagement of an enemy platform. A needline is a description of the information that moves from one activity to another, such as a tactical plan, by some automated or manual route.[17]

The SV describes the system-level structures that support the OV's. The SV includes the systems required at each node, the communication media connecting the nodes, and the functions contained within each system. In addition, this view contains tables describing how each needline listed in the OV products is implemented by the

communication media listed in the SV products and tables. These tables show how each activity described in the OV products maps onto the functions described in the SV products.[18]

The TV describes the minimal set of rules governing the arrangements, interactions, and dependencies of system components. This view includes standards used in the SoS, and the commercial off the shelf (COTS) and GOTS components used.[19]

A fourth set of products, the AV, includes two products that provide an overview perspective of the entire system. Figure 2 illustrates the relationships among the three primary views of the architecture framework.
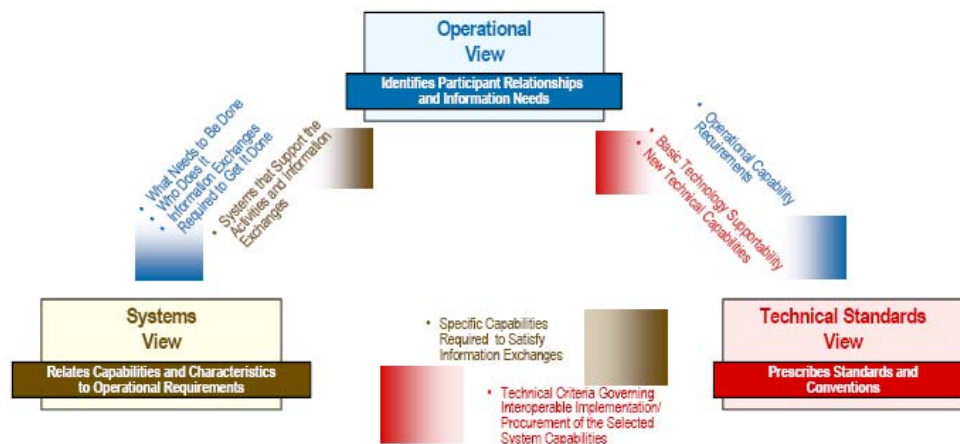
Figure 2.   DoD Views' relationships

The high-level operational concept should drive the OV. The OV in turn drives the SV to identify shortfalls and systems requirements drive the TV to address a common set of applicable standards. To be internally consistent and integrated, an architecture description must provide explicit linkages among its various views. Figure 2 illustrates the primary linkages among the three views. In Figure 2, the OV describes the nature of each information exchange in detail sufficient to determine the degree of operational interoperability required. The SV identifies which systems support the operational requirements, translates the required degree of interoperability into a set of system data exchanges executed by system functions, and compares current/postulated implementations with the required operational capabilities. The TV articulates the

criteria that govern the compliant implementation of each required system that will result in the fielding of an interoperable system. Thus, the three views and their interrelationships provide the basis for deriving measures such as interoperability or performance and also provide the basis for measuring the impact of the values of these metrics on operational mission and task effectiveness.[20]

4. Summary

The DoDAF provides a common approach for developing architecture descriptions and a basic foundation for relating architectures. The framework is intended to ensure that architecture descriptions can be compared and related across organizational boundaries, including Joint and multinational boundaries.[21] The framework also provides a critical mechanism for understanding operational concepts and their relation to capabilities, anticipating changes in operational concepts or changes in automated capabilities, and acquiring both material and non-material assets.[22]

The DoDAF has a set of guiding principles, compliance guidelines and a generic process for developing an architecture description as shown in Figure 3. This process must be adapted to an individual business needs or tailored to the needs of the particular organization. It is intended to provide guidance for the architect who is applying the framework.
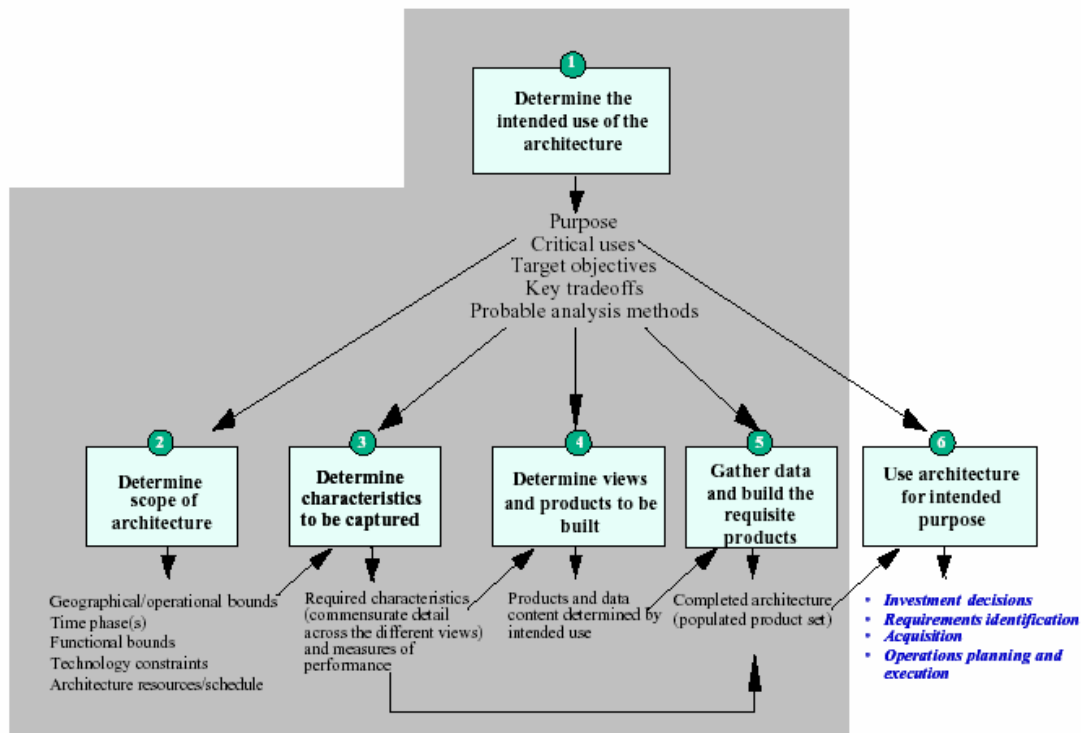
Figure 3.   Determining Use of Architecture

The capabilities of the DoDAF are vast in that it provides common language and structure, the ability to have an integrated and interacting architecture for DoD platforms and creates a functional development process for those architectures, and provides architecture focus for the development of software intensive products

C.   ZACHMAN FRAMEWORK (ZF)

The Zachman architecture framework was developed by John Zachman for use by organizations as they embarked upon various enterprises. It serves as an organizational tool in developmental efforts.

1.   Purpose of ZF

In 1987, John Zachman, wrote: "To keep the business from disintegrating, the concept of information systems architecture is becoming less of an option and more of a necessity." From then on, the enterprise architecture framework of Zachman has evolved and become the model around which many major organizations view and communicate their enterprise information infrastructure. It provides a blueprint, or architecture, for the organization's current and future information infrastructure.[23]

In his white paper "A Disciplined Approach to Managing Enterprise Information Systems Architectures", Robert W. Ridlon, Jr. submits the following abstract: Organizations, in both the public and private sectors, are undergoing relentless change. They face the inevitability of environmental change, politically, technologically, and economically. This dynamic environment has brought with it a demand for the right information as a critical resource for organizational success. It is not merely the availability of information, but more importantly the quality of information. In addition to the information, the technology for managing it also continues to change. In our dynamic environment, missions change, strategic plans follow, and new organizational goals and objectives are set. This changes the needs of the decision-makers and front – line users of information. As their information needs change, there must be a mechanism for effectively and efficiently identifying these needs and once identified, translate them into a solution that is accepted by the information user.[24]

2.   History of ZF

John Zachman worked in the information strategy community in the late 1960's and early 1970's and noticed that in project after project his team was having problems getting from strategy, which they understood well, to implementation, which his team did not understand. He felt that information strategy groups needed a way to bridge the gap between strategy and implementation and establish an environment that was conducive to change with the upgrade in technology.

In 1972, Zachman moved to the Los Angeles area, where he began to do information strategy work for air-frame manufacturing companies. He and others in his industry were struck by the fact that the enterprise systems they were attempting to build and implement were strikingly similar to the manufacturing of airplanes – both were complex exercises of product development and manufacturing processes. However, the airplane manufacturers had figured out the architecture of airplanes and what it took to move from strategy to implementation. They were able to produce a produce a product that: 1) Was relevant to the marketplace; 2) was able to be assembled piece by piece, unit by unit , sub-assembly by sub-assembly; and 3) maintainable over time in the face of a changing marketplace and technology, with little obsolescence.

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The problems faced by Zachman and others working in the information strategy field were that their product (system) was not relevant to the marketplace (enterprise) in its final form, and if not relevant at the time of marketplace entrance, it had no life cycle to be concerned with. Zachman's dilemma was to discover or construct an architecture that would provide for the meeting of the three constraints mentioned above: 1) Relevance to the marketplace; 2) ability to be readily assembled; and 3) maintainable and able to be upgraded over time.

John Zachman learned, not only from engineering and manufacturing, but from other 'old world' trades such as architecture and construction where the conceptual structures are identical. He discovered that while there is not a simple architectural representation for a complex product, there is a set of representations of a complex product. There are representations from different perspectives, or roles, being played in the process of producing the product. For example, there are representations of the end product from the perspective of the customer, or ultimate 'owner;' from the perspective of the engineer, or 'designer;' and, from the perspective of the manufacturing engineer, or 'builder' of the product; along with some other perspectives. There are also intersecting representations of the different characteristics of the product. For example, there are representations of the material composition of the product from the perspective of the builder, etc. Likewise, there are intersecting representations of the function and geometry of the product from the perspectives of the owner, designer and builder.

However, in John Zachman's words the breakthrough realization was that the representations of the intersecting characteristics, that is 'material,' 'function,' and 'geometry,' were actually descriptions of WHAT the product was made of, HOW the product worked and WHERE the components were located relative to one another. From that observation, it was obvious that a comprehensive description of WHO does what relative to the product, WHEN do things happen and WHY are various product choices being made.[25] This resulted in Zachman building and publishing (in 1987) the enterprise framework that bears his name (Figure 4).

Figure 4.   Zachman Framework

3.   Capabilities of ZAF

Many books have been written to establish why the ZAF was written and even more books have been written on its usage. Some of those authors have worked in tandem with Zachman, but more have not, so some of the interpretations are of a significance value because they are written from the perspective of direct application. This thesis will examine what John Zachman, the author of the ZAF, gives as capabilities and what others see as capabilities of the ZAF.

The framework is a schema for classifying and organizing the topics related to managing the enterprise, as well as to the design, development, and manifestation of the enterprise. The framework is also a classification schema for organizing descriptive representations (artifacts) of an enterprise.[26] Through this classification and organization of topics, the framework can assist the organization in becoming more accountable and

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responsive.[27]   The organization can be a variety of enterprises such as a business, governmental agency, family or an individual. In the fast paced, changing environment in all sectors and domains, one must successfully adapt and this requires integration, alignment and responsiveness. The Zachman framework helps pull together people and technology to create a successful, competitive enterprise.[28]

Figure 4 shows the Zachman framework for an enterprise architecture.   The framework describes a holistic model of an enterprise's information infrastructure from six perspectives: planner, owner, designer, builder, subcontractor, and the working system or functioning enterprise and six aspects: who, what, when, where, how and why.[29] The perspectives represent viewpoints whereas the aspects represent subject areas. The framework tells a story of completeness because its six perspectives and six aspects form a holistic representation of the enterprise.[30] The framework contains six rows and six columns and at the intersection of each row and column is a cell for a total of 36 cells. Each cell represents a fundamental piece of knowledge relative to the row and column and is known as a primitive. Having complete knowledge of each primitive is relative to understanding the functioning enterprise. A comprehensive knowledge base (knowledge of all the primitives) helps one to understand and determine whether the functioning enterprise is working appropriately. An appropriately functioning enterprise is one that is aligned, flexible, integrated, and responsive.[31]

Although the framework is intended to be generic, it follows a good software pattern by listing each cell with a descriptive template. Each cell in the framework is illustrated with a sample icon, an appropriate primitive model description, and a primitive component. Figure 5 shows a sample icon.
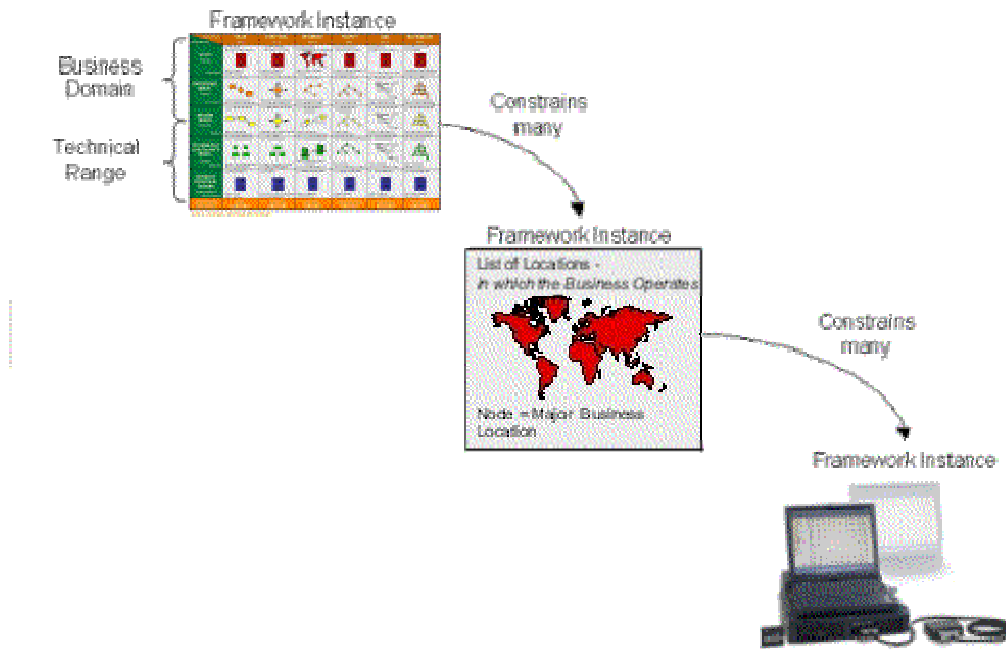
Figure 5.   Graphical display of cell

Each cell is the intersection of a perspective (constraint) and an aspect (variable) – the rows and columns, respectively, of the framework. The framework hieroglyphic implies that if knowledge from each cell is made explicit, the functioning enterprise will be:

- Operational

- Aligned to each part of the enterprise

- Flexible

- Adaptable

- Able to embrace change[32]

  a.   Perspectives

  There are six perspectives in the framework and they can be classified as:

- Principal

- Empirical

- Certifiable

The principle perspectives of the framework are the owner, designer and builder (rows 2, 3 and 4) because these are the primary perspectives of architectural design. Each perspective is contextual in that the problem area is viewed as a whole. Needing to view the entire problem area holistically is a trait of the principal perspectives.[33]

The owner's perspective is identified as row 2 of the framework. He/she is often the intended recipient of the final product or service and the artifacts produced represent the desirable characteristics of the product or service and the artifacts show what the owner is going to do with the product or service. The owner's perspective is a conceptual view of the final product or service.[34]

The designer's perspective is identified as row 3 of the framework. The designer is the engineer or architect of the final product or service and he/she is the intermediary between the owner and builder. The artifacts produced by the designer represent the laws of nature, the system or the logical constraints of the product's or service's design. The designer has a logical view of the final product or service.[35]

The builder's perspective is identified as row 4 of the framework. The builder is the manufacturing engineer or general contractor of the final product or service. The builder applies the physical constraints of what is possible to the designer's artifacts – he/she understands how the product can be built and used. The builder's perspective is a physical view of the final product or service.

The empirical perspectives of the framework are the planner and subcontractor (rows 1 and 5). The planner's perspective is contextual regarding the problem area, however the subcontractor's view is non-contextual in that his/her artifact depict the product disassembled into parts, so that the product or service can be manufactured piece by piece and then assembled into the final product.[36]

The planner's perspective is identified as row 1 of the framework. The planner provides scope for the enterprise in that he/she establishes the context for the enterprise, inner and outer limits and the list of relevant constituents which must be accounted for in the artifacts of the other perspectives.

The subcontractor's perspective is identified by row 5 of the framework. He/she creates the detailed descriptions that disassociate the parts or pieces of the complex object for purposes of manufacturing. The subcontractor is out of context and seeks to fabricate and assemble all the necessary components.[37]

The certification perspective is the functioning enterprise and there is no artifact representation because the functioning enterprise is the culmination of the other perspectives and is the real thing.

The functioning enterprise perspective is identified by row 6 of the framework. The functioning enterprise is the physical materialization of the product or service and is the result of what is articulated through artifacts. Certification is a formal declaration from the designer, builder, and subcontractor to the owner that the functioning enterprise is as the owner described.[38] Therefore, row 6 represents the functioning product, goods or services and what the users will experience.

b. Aspects

The framework's viewpoints or perspectives are represented horizontally as rows, whereas the framework's subject areas or aspects are represented vertically as columns. The framework's aspects are based solely on the six primary interrogatives of the English language: what, how, where, who, when and why because they can answer or address all questions.[39] This approach normalizes the framework and reduces facts and questions to one location within the framework, which makes it (the framework) an effective communication vehicle.

The six aspects of the framework – what, how, where, who, when, and why – represent the independent variables in a complete, normalized domain:

- What – is it made of?

- How – does it work?

- Where – are the components located?

- Who – performs what functions?

- When – does something happen?

- Why – do things happen?

The framework's aspects indicate the primitive units of measure for evaluating an enterprise in action. The six units of measure are inventory, yield, capacity, performance, duration and state:

- What – inventory – for the things of interest

- How – yield – for each process

- Where – capacity – for each node

- Who – performance – for each work function

- When – duration – for the response time and cycles

- Why – state – for desire and is associated with quality[40]

John Zachman has repeatedly stated that the columns of his framework have no particular order, but for simplicity sake this study will assume order. The columns of the framework represent the six interrogatives of the English language: what, how, where, who, when and why.

What is the first column of the framework and denotes the material composition of the enterprise.[41] This column is a centerpiece for all relationships throughout the enterprise and identifies the things that matter.

How is the second column of the framework and denotes the transformations caused by the processes of the enterprise. A transformation is an input to a process that is altered in some way to form an output – process begets process.[42]

Where is the third column of the framework and denotes the connectivity between the enterprise's node points.[43] This column often forms the geometry of the enterprise and is of importance to the owner and planner because it serves as a conduit to distribute goods and services.

Who is the fourth column of the framework and denotes the collaboration, responsibility, or workflow of the organization and its people. The focuses of this aspect are performance, worker interactions and security.[44]

When is the fifth column of the framework and denotes the dynamics and timing of the enterprise. This aspect focuses on the triggers that cause events in the enterprise and the schedule that handles each type of event.[45]

Why is the sixth column of the framework and denotes the strategy, plans, direction, values and guidance. The focus of this aspect is the motivation for the purpose and survival of the enterprise.[46]

c.   *Cells*

The intersection of a single row and a single column is represented by a primitive cell that represents an artifact because it is from a single constraint (the perspective) and a single variable (the aspect). A model is a typical artifact used for representing the contents of a cell for any domain. A model based on a single cell is a primitive model. The contents of a primitive model are a series of primitive components. Primitive models are the basis for producing enterprise architectures. If the enterprise is not described using primitive components and primitive models, then the architecture is being compromised.[47]

Each cell has two dimensions: scope and detail. Scope is the complete outlook of the artifact and detail is the level of description contained in the artifact. When everything about a primitive has been recorded in an artifact, the artifact has reached a level of excruciating detail which is the contents of the artifact being complete in all respects. The artifacts of a cell can include high-level, mid-level and low-level views, all of which serve to describe the scope and detail dimensions at various stages.

The framework's cells do not build upon each other; rather they are primitive models which have characteristics of scope and detail that defines its artifact. Each cell is independent of each other. Each cell can be integrated with every other cell in the same row and transformation occurs vertically between rows. Navigation between cells occurs vertically up or down a column or horizontally along a row but not diagonally between rows.

The principle of reusing components in an enterprise is a desirable attribute and the primitive nature of each cell in the framework lends itself to producing

normalized and standard interchangeable parts. Each cell in the framework has scoped and detailed artifacts and components that are engineered from the details in each cell are built for reuse.

4. Summary

The Zachman framework is a writing system, a planning tool, and a problem-solving tool. Its characteristics can be summarized as follows:

- Simple to use

- Comprehensive in structure

- Neutral to method of practice and technology

- Ubiquitous[48]

The framework is a writing system because it allows architects to use common language as opposed to technical language in their planning efforts.

The framework is a planning tool because it presents architects with a holistic view of an enterprise which improves decision making.

The framework is a problem-solving tool because it allows architects to focus on one aspect of the enterprise without losing focus on the complexity of the entire enterprise.

The framework is simple to use because it is based on logic rather than a specific method, technology or a need. It sums up an enterprise in its entirety and is comprehensive in scope and detail. All specific issues of an enterprise can be mapped to a particular cell of the framework to see how it fits in the overall context of the enterprise.

The framework is comprehensive in structure because it presents a holistic view of an enterprise by presenting six perspectives (rows) and six aspects (columns) and their intersections (36 individual cells) which are primitive models, which comprise primitive composites which describe the enterprise in detail.

The framework is independent of method, technology or need. It can be applied to any decision making enterprise.

The framework is ubiquitous in that it is not limited to information technology or business. Its principles can be applied to family matters, education, laboratory work or any other enterprise requiring planning and decision making.

III. RESEARCH METHODOLOGY

A. INTRODUCTION

When one begins a project, he/she must begin with a set of expectations, directions, and limitations which will serve to lead to the completion of the project. This thesis did not consider various frameworks such as the TOGAF or DoD Enterprise Architecture 2 Business Reference Model for use as the architecture for the WPC's system of systems document because their application would not be in line with the direction of this study. This thesis researches and compares the DoDAF and Zachman framework for use as the architecture framework for the system of systems document for the USCG's WPC.

B. RESEARCHING DODAF

1. Initial Expectations

When studying a complex document that is designed to be a working framework for the development of an enterprise, it is expected that the document will yield criteria of high grade quality. In the case of the DoDAF, it was expected to be simplistic, logical, comprehensive and structural in its capabilities to define, integrate and manage the development of software-intensive systems for usage by the United States military.

The DoDAF is simplistic in that it breaks down a complex structure into three simple views: The Operations View (OV), the System View (SV) and the Technical View (TV). Each view is further broken down into sub-views or framework products: OV has 9 sub-views; SV has 13 sub-views and the TV has 2 sub-views. Each sub-view is an architecture product which is used to develop an architecture description.

The DoDAF is logical in that it guides the architect or architecture team to the completion of an integrated process. Each product describes a function which must be completed to establish the enterprise. The OV has 5 products whose usage is mandatory, while the SV has 9 products whose usage is mandatory and both Technical Views are to be used in all situations. The DoDAF also has two All Views (AV) products which contain the scope, purpose and Integrated Dictionary of the entire project.

The DoDAF is comprehensive in that it defines the enterprise in totality, from conception to design to implementation through verification and validation, through upgrades and final disposal. The framework stimulates the architect to produce a product that can grow as the product grows and be upgraded as technology changes and software requirements migrate.

The DoDAF is highly structural in that it provides a sturdy framework or base from which to begin building an architecture description. The three views (Figure 2): OV, SV and TV are interrelated and have a degree of interoperability so that their combined composition forms a firm base from which the entire enterprise structure can be built. The high-level operational concept drives the OV and the OV drives the SV to identify shortfalls and systems requirements. The SV requirements drive the TV to address a common set of applicable standards.[49] This describes part of the fundamental linkages among the views.

The DoDAF is a framework tool used to integrate various architecture products into an architecture description. After studying the various aspects of the DoDAF, the initial expectations of the user to be able to apply the framework simplistically, in a logical manner, comprehensively and structurally can be met.

2.   Initial Pros

The proficiencies of the DoDAF are too numerous and making a comprehensive list of all of them is not within the scope of this document. However, some of the initial pros of the DoDAF are that it is organizational, informational, and is a networking document.

The DoDAF is organizational in that it provides structure throughout the entire document. The framework provides a working, upgradeable product that can be used to efficiently and effectively manage a software-intensive project from its inception to its disposal. It is a combination of three major views which are interoperable and interrelated. Each of those views is further divided into products – some of which are of higher detail than other products. The architect using the framework is given guidance in how to move from one product to another. Each product is specified in terms of

templates and information to capture in each product and the integration of the individual products make up an architecture description.

The DoDAF is informational in that it provides specific instructions and guidance on its usage. The framework is partitioned into two volumes and a deskbook:

- Volume I provides definitions, guidelines, and related background material.

- Volume II contains descriptions for each product.

- The DoDAF Deskbook provides supplementary information to framework users.

The framework also provides instructions on how to develop and determine the use the architecture (Figure 3). In its informational effort, the framework dedicates an entire volume to the description of architecture products and their usage in the development of an architecture description.

The DoDAF is networking at its core. The OV, SV and TV views are networked together to achieve a firm base for the growth of an enterprise. The framework provides a network such that the architecture description developed by its guidance will integrate with other architectures developed by its guidance. The capabilities of DoD to perform Net-Centric Operations and Warfare are further enhanced by the networking aspects of the framework. The DoD must have the ability to portray and understand complex many-to-many relationships and to achieve that, the architects of various military Net-Centric systems employ the DoDAF because of its ability to portray a holistic view of a system while integrating the products that describe the system. The OV, SV and TV views have 24 products that are networked together to form an architecture description.

3. Initial Cons

The DoDAF, like all other products used for enterprise architecture, has drawbacks, hurdles, shortcomings and disadvantages. Some of those consequences are based on the fact that different projects demand different approaches and they require

different outcomes. However, some of those consequences reside within the document itself. Some of the initial cons of the DoDAF are that it is cumbersome, inelastic, and unalterable.

The DoDAF is cumbersome in that it is a huge document. The framework is divided into two massive volumes and a deskbook. Volume I provide definitions and guidelines for its usage. Volume II contains ponderous descriptions for each of the 26 products contained within four views: the AV, OV, SV and TV. The deskbook provides supplementary information to framework users. An inexperienced or beginning architect can be overwhelmed by the tremendous amount of information that is found in the DoDAF. It is not unlike many other DoD products that are overwhelmingly wordy and over-illustrated.

The DoDAF is inelastic in that it follows a direct path with little variance. Within its product descriptions, the framework leaves little room for tolerances or diversions from its intended results. The development of architecture products is micromanaged throughout the framework. Each product description has a product definition, product purpose, product detailed description, UML representation, data element definition, and a Core Architecture Data Model (CADM) support paragraph. While this is not inherently bad, it is an example of the inelasticity of the framework.

The DoDAF is unalterable in that it takes an act of Congress to initiate changes. The Clinger-Cohen Act of 1996 focused the need for Federal Agencies to improve the way they select and manage information technology (IT) resources and the DoDAF grew out of this and related policies that identified the need for a unified architecture framework to be applied during the development of those architecture descriptions dictated by policy.[50] An architect of a military software-intensive project must follow the guidelines as dictated by the framework.

C. RESEARCHING ZF

1. Initial Expectations

In 1987, John Zachman, author of the Zachman Framework for Enterprise Architecture, wrote "To keep the business from disintegrating, the concept of information systems architecture is becoming less of an option and more of a necessity." From that

assertion over 15 years ago, the Zachman Framework for Enterprise Architecture has evolved and become the model around which major organizations view and communicate their enterprise information infrastructure. After studying the Zachman framework, the initial expectations of the user is to be able to apply the framework simplistically, in a logical manner, and comprehensively.

The Zachman framework is simplistic in its structure. It is composed of six perspectives which are represented by the six rows of the framework: from the top down – the planner, owner, designer, builder, sub-contractor and the functioning enterprise; those are the participants involved in information systems planning, development, and usage. The framework has six columns which are its aspects and they answer the six interrogatives: what, how, where, who, when and why. At the intersection of the columns and rows are cells which are a unique artifact and contains a unique dimension that cannot be found in another cell. The framework is simplistic in this manner.

The Zachman framework is logical in that an architect can look through the eyes of each perspective and examine their process by examining each individual cell in their rows and those cells in the framework can be presented at various levels of detail/granularity. The flow of details and information follows a distinct pattern left to right on the rows and up and down on the columns, but not diagonally.

The Zachman framework is comprehensive in that it encompasses the six interrogatives: what, how, where, who, when and why. Those questions are assumed to be the total relevant set with no further questions that can be asked. Each question is unique and if one answers all six questions about any subject or object - that represents completeness and total comprehensiveness.

2.   Initial Pros

The proficiencies of the Zachman framework are too numerous and making a comprehensive list of all of them is not within the scope of this document. However, some of the initial pros recognized within the Zachman framework are that it is organizational, neutral, is a networking tool and is an excellent methodology.

The Zachman framework is organizational in that it has dimension necessity and simplicity. All six dimensions are needed to fully represent each perspective – the

integration of all cell models in one row constitutes a complete model from the perspective of that row. Each column has a simple, basic model used to describe a portion of the enterprise and its architecture. These models are not independent: rather they are interdependent and interact continuously. A change in one column affects one or more columns.

The Zachman framework is neutral in that it can be applied to all types of projects. Most architecture frameworks are project specific; they are useful for one type of activity. However, the Zachman framework is unique in that it answers the six interrogatives for any project and it encompasses the perspectives that are used in all projects. The neutrality of the Zachman framework makes it a viable instrument for use by organizations and enterprises of all types and sizes.

The Zachman framework is a networking document in that it integrates all of its cells to form an architecture description. The cells of the framework are the result of the intersection of a perspective and an aspect; they form a unique artifact that has context and dimension. Each cell contains graphic and textual description and is unique in that the information contained within its boundaries cannot be found throughout the framework. It is the final integration of all the cells that form the enterprise.

The Zachman framework has all the characteristics of an excellent methodology. It address the full life cycle of an enterprise, integrates a set of processes, provides executable results, communicates well to all audiences, extends ability to adjust to specific needs and has been applied successfully.

3.   Initial Cons

The Zachman framework, like all other products used for enterprise architecture, has drawbacks, hurdles, shortcomings and disadvantages. Most of those consequences reside within the document itself. Some of the initial cons of the Zachman framework are that it is primitive, and lacks cognitive and business direction.

The Zachman framework is primitive in that each one of its columns answers one of the six interrogatives of the English language: what, how, where, who, when and why.

While this is a comprehensive approach to solving the design problems of an enterprise structure, it does not allow for decomposition which is necessary for problem solving for the complex enterprise.

The Zachman framework lacks cognitive direction in that it does not give concise direction and guidance for problem solving. It is not a document, but is a simple framework and as a result it does not provide rules and regulations for its usage. The framework is generic in scope and is not tailored to a specific program or project. It does not provide technical assistance or details for oversight of a project.

The Zachman framework lacks business direction. It does not provide details for the establishment of the business portion of an enterprise development. In the words of John Zachman, the creator of the Zachman framework, the framework is not designed to sell anything. It is simply a classification scheme for descriptive representations of complex objects. Business rules, guidance and direction have to be incorporated by the architect(s).

D.   COMPARISON OF DODAF TO ZACHMAN FRAMEWORK

In 1987, John Zachman, author of the Zachman Framework for Enterprise Architecture, wrote "To keep the business from disintegrating, the concept of information systems architecture is becoming less of an option and more of a necessity." Zachman's concern was that change (especially information technology), as an inevitable characteristic of human endeavor, was not being recognized and addressed by the business enterprise. Drawing upon his work experience in information systems, Zachman's response to this paradox was to develop and introduce the Zachman Architecture Framework in 1987. It is a widely used approach for developing and/or documenting enterprise-wide information systems architecture.

"The Defense Science Board and other major studies have concluded that one of the key means for ensuring interoperable and cost-effective military systems is to establish comprehensive architectural guidance for all of DoD." [USD (A&T), ASD (C3I), J6, 1997]. In the mid 1990's with the increasing focus on joint and multinational operations, DoD realized the need for a common approach for describing architectures. In October 1995, the Deputy Secretary of Defense directed that a DoD-wide effort be

undertaken to define and develop better means and processes for ensuring that Command, Control, Communications, Computers and Intelligence capabilities meet the needs of the warfighter. The C4ISR Architecture Framework, Version 1.0, dated 7 June 1996, was developed. The utility of the C4ISR Architecture Framework, combined with both Federal and DoD policy encouraging the use of architectures, led DoD to evolve the document into the DoDAF in 2003.[51]

The Zachman framework is a way of thinking about an enterprise in an organized way so that it can be described and analyzed. The columns represent aspects of the enterprise that can be addressed, and the rows represent various viewpoints from which those aspects can be described. At the intersection of a column and row is a cell that represents an aspect of the enterprise modeled from a particular point of view. The architect selects and models the cells that are appropriate to the purpose of the analysis.[52]

Figure 6 is illustrated by color coding and shows how the views and individual products of the DoDAF map to the cells of the Zachman framework. (The figure maps only the most frequently-used DoD products, not all of them.)

Blue cells indicate that DoDAF contains operational view products that map to the cells; orange cells indicate that the DoDAF contains system products that map to the cells; and blue/orange cells indicate that the DoDAF contains both operational and systems products that map to the cells. The ovals have been overlaid onto the color-coded cells. These ovals represent individual products from the DoDAF that correspond to the Zachman cell or cells onto which the oval is overlaid. Operational products are represented by blue ovals and systems products by yellow or orange ovals.

In some instances a cell is blue and orange, indicating the DoDAF contains both operational and systems products that correspond to the cell, but only a blue oval is shown in the cell because not all DoDAF products are represented. The Function/Designer cell is blue and orange because the Operational Activity to Systems Function Matrix, while shown in the DoDAF as a system view product, is actually a pivot between the operational and systems views.

Through this product-to-cell mapping, the DoDAF can provide templates and guidelines for modeling the enterprise features that correspond to the Zachman cells. Refer to Appendix A Table 1 to map DoDAF product names to the framework product and general description.[53]
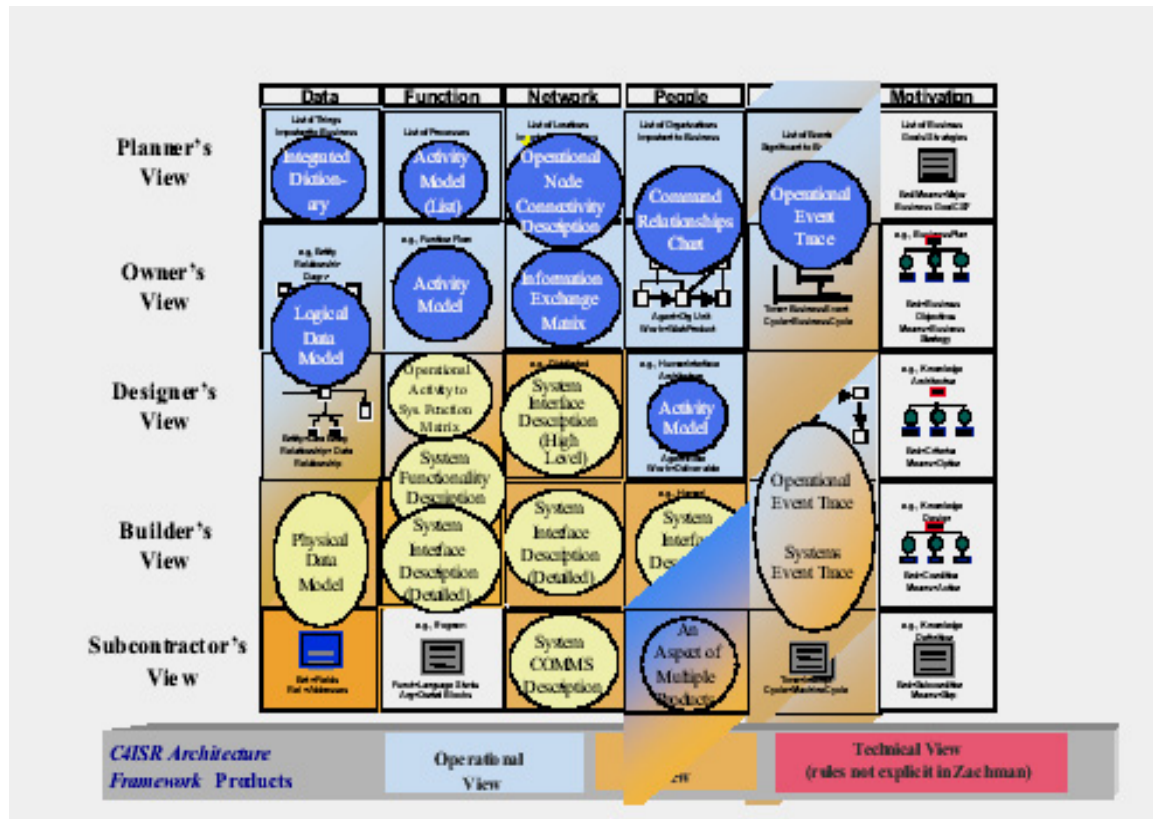
Figure 6.   Mapping of selected DoDAF products to ZAF cells

E.   DEVELOPING A SURVEY

1.   Deciding Survey Length

This thesis will analyze and compare the Department of Defense Architecture Framework and Zachman Architecture Framework for use as the USCG's WPC System of Systems architecture. At the beginning of the project, a determination was made to survey a pool of managers and directors responsible for the application of architecture frameworks to large, complex DoD projects.

A short survey of ten questions was developed because many of the managers and directors surveyed have many constraints placed on their time.

2. Establishing Effective Survey Questions

This thesis compares two architectures for use as the USCG's WPC System of Systems architecture. To avoid random data collection, the survey posed to the managers and directors asked basic questions concerning their use of Architecture Frameworks. The following is a list of the questions used in the survey:

1. Have you ever participated in the application of an architecture framework? (YES) (NO)

2. Of the following architecture frameworks, which one(s) have you used?

    Department of Defense Architecture Framework

    Zachman Architecture Framework

    Other (please specify)

3. Which architecture framework would you recommend?

    Department of Defense Architecture Framework

    Zachman Architecture Framework

    Other (please specify)

4. Did the C4ISR architecture framework used on your project –

    Add value to the project? (YES) (SOMETIMES) (NO) (NA)

    Create unnecessary work?

    Assist in the architecture development of the project?

    Hinder development of the project?

    Increased functionality of the project?

    Have clear and concise documentation?

5. Did the Zachman architecture framework used on your project –

    Add value to the project? (YES) (SOMETIMES) (NO) (NA)

    Create unnecessary work?

    Assist in the architecture development of the project?

    Hinder development of the project?

    Increased functionality of the project?

    Have clear and concise documentation?

6. What are the best and worst functions of the C4ISR AF?

7. What are the advantages and disadvantages of using the C4ISR AF?

8. What are the best and worst functions of the Zachman AF?

9. What are the advantages and disadvantages of using the Zachman AF?

10. In your opinion, is an architecture framework needed for large scale, complex projects? Explain.

No research was conducted to establish questions of the survey or the length of the survey.

F. SUMMARY

The DoDAF and Zachman frameworks are used to develop enterprise architecture descriptions. The DoDAF is primarily used by DoD contractors and Federal Agencies to provide guidance for describing architectures for both warfighting operations and business operations and processes. Its purpose is ensure that architecture descriptions can be compared and related across organizational boundaries, including Joint and multinational boundaries.[54] The Zachman framework is a widely used approach for developing and/or documenting enterprise-wide information systems architecture. Its purpose is to provide a basic structure which supports the organization, access, integration, interpretation, development, management, and changing of a set of architectural representations of the organizations information systems.[55]

A compilation of initial expectations met by the DoDAF include an ability to apply it simplistically, logically, comprehensively and structurally. Likewise, the Zachman framework can be applied simplistically, logically and comprehensively.

The initial proficiencies of the DoDAF are that is highly organized, informational, and is a great networking document. Likewise, the Zachman framework is highly organized, a neutral document, an excellent networking tool and an excellent methodology.

The initial cons of the DoDAF are that it is cumbersome, inelastic, and unalterable, while the Zachman framework is primitive, lacks cognitive and business direction.

Both the DoDAF and Zachman frameworks are excellent tools used to provide structure and a holistic view to the development of an enterprise.

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IV. DATA ANALYSIS

A. INTRODUCTION

This thesis compares two architecture frameworks – the DoDAF and the Zachman framework for use in developing the System of Systems architecture document of the USCG's WPC. In the beginning stages of this project, it was decided to poll supervisors, managers, and directors at two defense contractors (Northrop Grumman Ship Systems and Raytheon) concerning their application of the aforementioned frameworks. A survey was developed and sent out on May 14, 2005 to sixty-seven supervisors, managers and directors of the two companies mentioned, polling them about their usage of the DoDAF and Zachman framework. There were eighteen responses to the survey, which is a twenty-seven percent response rate. This chapter will analyze data collected from the survey.

B. SURVEY RESULTS

1. Have you ever participated in the application of an architecture framework?

   - Of the eighteen responses, seventeen responded yes (94.4%) and one responded no (5.6%).

2. Of the following frameworks (DoDAF, Zachman) which ones have you used?

   - Of the eighteen responses, thirteen responded DoDAF (72.2%), four responded Zachman (22.2%) and four responded 'other' (22.2%).

3. Which architecture framework (DoDAF, Zachman) would you recommend?

   - Of the thirteen responses, six responded DoDAF (46.2%), one responded Zachman (7.7%) and six responded 'other' (46.2%).

4. Did the DoDAF (C4ISR) architecture framework used on your project –

   - Add value to the project?
     57% yes, 36% sometimes, 0% no, 7% not applicable
   - Create unnecessary work?
     0% yes, 86% sometimes, 7% no, 7% not applicable

- Assist in the architecture development of the project?

  60% yes, 33% sometimes, 0% no, 7% not applicable

- Hinder development of the project?

  7% yes, 21% sometimes, 64% no, 7% not applicable

- Increased functionality of the project?

  23% yes, 38% sometimes, 31% no, 8% not applicable

- Have clear and concise documentation?

  14% yes, 71% sometimes, 7% no, 7% not applicable

5. Did the Zachman architecture framework used on your project –

- Add value to the project?

  8% yes, 8% sometimes, 0% no, 85% not applicable

- Create unnecessary work?

  0% yes, 15% sometimes, 0% no, 85% not applicable

- Assist in the architecture development of the project?

  15% yes, 0% sometimes, 0% no, 85% not applicable

- Hinder development of the project?

  0% yes, 15% sometimes, 0% no, 85% not applicable

- Increased functionality of the project?

  8% yes, 8% sometimes, 0% no, 85% not applicable

- Have clear and concise documentation?

  0% yes, 15% sometimes, 0% no, 85% not applicable

6. What are the best and worst functions of the DoDAF?

- Of eighteen responders, five answered this question as follows:

  a. Sometimes can be more of a hindrance then helpful

  b. Best – relational data repository pictorial representation of the data; Worst – inconsistency of interpretation by some users.

  c. What is a 'function' of a framework?

d. Best – defines some standard products and relationships between them; Worst – doesn't define a process, doesn't help with some architectural perspectives, and totally misses the boat on hierarchical architectural relationships.

e. Don't understand the question.

7. What are the advantages and disadvantages of using the DoDAF?

- Of eighteen responders, seven responded to this question.

a. Adv – organize thoughts; Dis - Sometimes can be more of a hindrance then helpful.

b. The documentation is very loose and easily interpreted in many different ways. This can make it difficult during the creation of certain products when people on the same project have different ideas as to what the product 'should be'. Also, special attention needs to be paid to the entire framework and how the whole product set is to work together. This can help alleviate issues with different interpretations of the documentation and limit issues later.

c. Zealousness of management to ensure that every work product include every CAF/DoDAF artifact results in numerous poor quality artifacts that don't tell you anything. For example, including SV artifacts in a preliminary requirements project. There isn't much understanding in our industry about what an artifact should show and when to use it. Our company should invent in very detailed training for system engineers.

d. Advantage: pictorial representation of the data organized relational data repository; disadvantage: when the architecture teams try to duplicate work that is being done by another group; thus causing double work and sometimes lack of consistency tool use by all of the team would increase the understanding and consistency of product.

e. Advantage: commonality across most DoD programs; Disadvantage: too few views; many significant concepts have no natural home (e.g., information assurance (security) architecture).

f. People understand what an OV-x or SV-y view is supposed to represent.

g. The advantages are that it provides documentation of existing C4ISR system architectures and instills some discipline into the architecting process. The disadvantage is that it does not provide a concise over-arching view of the entire architecture. One has to page through the various views and try to remember them all in order to obtain a coherent picture.

8. What are the best and worst functions of the Zachman Architecture Framework?

- Of the eighteen responders, six answered this question as follows:

a. NA

b. NA

c. not applicable

d. NA

e. Best – it's a great thinking tool. Worst – probably not a great way to describe architecture.

f. Haven't used it.

9. What are the advantages and disadvantages of using the Zachman Architecture Framework?

- Of the eighteen responders, six answered this question.

a. NA

b. NA

c. not applicable

d. NA

e. It's a great tool for thinking about an architecture, and structuring analysis.

f. Haven't used it.

10. In your opinion, is an architecture framework needed for large scale, complex projects? Explain.

- Of the eighteen responders, nine answered this question as follows:

a. Yes. As indicated in the question, the complexity of such projects must have architecture framework to succeed.

b. It is helpful to use a framework to capture the whole project. Using a well-known framework makes it easy to understand for those outside of the project. It also helps to ensure that everything is being covered.

c. Yes, if implemented consistently and with sufficient documentation/instruction to team members an architecture framework greatly decreases the learning curve to understand the system and improves understanding of the architecture details.

d. Yes, the customer understands the data. The team understands the data from a team perspective.

e. No. It is more important to have an architecture process than a product framework. The process should describe the products. The framework is useful (but not sufficient) for the development of the process.

f. Yes, but it must be tightly coupled with the requirements tool(s) [DOORS] as well as within itself.

g. I think it's far more important that the architects understand frameworks that exist and use the products, views, processes, etc. that help with the particular project.

h. Yes

i. Yes, a framework is needed. If no framework is used there is no assurance that an architecture is correct. Also, since most systems need to be interoperable, architectures must be explained in some standard notation so that interoperability can be readily assessed.

C. SUMMARY

As a part of this thesis process, a survey was developed to assess how many technical directors, managers and supervisors have used the DoDAF or Zachman frameworks. The survey also assessed the advantages, disadvantages and the need for an architecture framework in developing large-scale, complex, software-intensive enterprises. The purpose of a survey is to collect information for use in improving products or processes. Once information is collected it must be assessed so its results can be put to effective use. Of the sixty-seven architects, directors, managers and supervisors the survey was sent to, eighteen responded and their comments are recorded in section B. This summary will catalog and assess the responses and comments of the survey.

The survey had a variety of questions and they are cataloged as directive, informational, and functional. Questions 1 – 3 asked the survey takers for their direction. Questions 4 and 5 supplied information for the survey takers so they could provide an assessment of the functional aspects of the framework that they had experience with. Questions 6 – 10 queried the survey takers for working knowledge and information pertaining to their experience in the application of an architecture framework.

This is a summary of the assessment of the information provided by the responders to this survey. The majority (94.4%) of responders had used an architecture framework during their career and most (72.2%) had used the DoDAF, while only twenty-two percent had used the Zachman framework. Forty-six percent of the responders would recommend the usage of the DoDAF, while seven percent would recommend the usage of Zachman framework. As indicated by the results, the majority of DoDAF users indicated that value was added to their work, sometimes unnecessary work was created by the use of the framework, the architecture development of the project was aided, did not hinder project development, increased functionality of their

project, and the framework had clear and concise documentation. As indicated by the results, the majority of Zachman framework users indicated that value was added to their work, the use of the framework sometimes added unnecessary work, the architecture development of the project was aided, sometimes project development was hindered, the functionality of their project increased and the framework had clear and concise documentation.

Based on the comments received, some advantages of using the DoDAF: a way of organizing thoughts, good as a pictorial representation of data repository, a way of establishing commonality, and a way of instilling discipline in the architecture process. Some disadvantages to using the DoDAF: can cause double work, views can be interpreted many ways, does not provide over-arching or holistic view of project, and has too few views.

Based on the comments received, the advantages of using the Zachman framework are that it is a great tool for thinking about a process and structuring analysis. A disadvantage to using the Zachman framework is that it is not a great way to describe an architecture.

The last question of the survey asked if the use of an architecture framework is necessary for large scale, complex projects. The overwhelming response was that an architecture is needed to structure the processes of developing an interoperable, network of systems. The results of this survey indicated that in DoD acquisition projects at Northrop Grumman Ship Systems and Raytheon, the DoDAF is the framework of choice.

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V.   IMPLEMENTATION OF ARCHITECTURE FRAMEWORK

A.   INTRODUCTION

"When Deepwater is complete," said Coast Guard Commandant ADM Thomas H. Collins, "our cutters and aircraft will no longer operate as independent platforms with only limited awareness of what surrounds them in the maritime domain. Instead, they will have the benefit of receiving information from a wide array of mission-capable platforms and sensors - enabling them to share a common operating picture as a part of a network-centric force operating in tandem with other cutters, boats, and both manned aircraft and unmanned aerial vehicles."[56]

The Deepwater system of systems is a collection of different elements that together produce results not obtainable by the individual elements alone. These include platform systems (aircraft, cutters and patrol boats), sub-systems (radars, radios, satellite communications, etc.) as well as individual components and assets (people, hardware, software, shore facilities).

All elements combine to generate capabilities needed to produce system-wide results.   The value added by the system as a whole, beyond that contributed independently by its individual elements, is created by the integration among the elements (i.e., how they are interconnected and combined in order to work together).

The elements are being designed to ensure the Coast Guard will possess and maintain seamless interoperability with the forces and agencies of the Department of Homeland Security, the Department of Defense (DoD), and other federal and regional agencies – a true force multiplier in the fullest sense.[57]

Extensive studies of the all Coast Guard mission areas takes into account detailed operational modeling of platforms and systems, optimized force mixes of varying size, asset application using various concepts of operation and timed incremental implementations across the life of the program.

Since the terrorist attacks inside the United States on September 11, 2001, the Coast Guard's mission demands, threats and operational priorities have changed considerably – including a 40 percent increase in resource usage and an exponential

expansion of homeland security requirements. Because of the need to remain flexible and responsive, the Deepwater program needs to be built upon a spiral development in order to respond to evolving technology or changes in mission requirements.
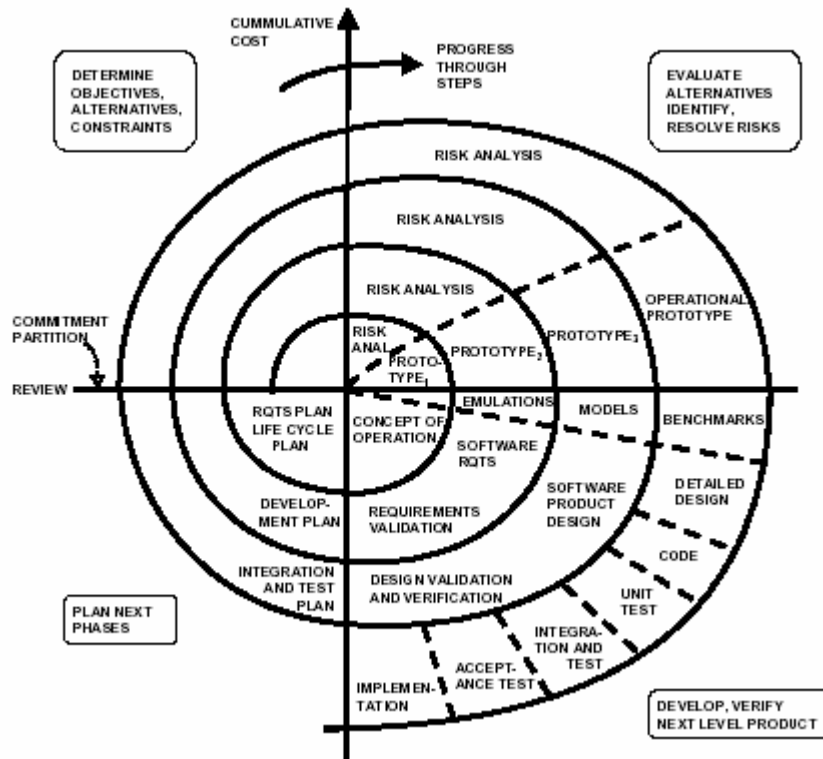
Figure 7.   Spiral Development

The spiral development as outlined in Figure 7 and proposed by Barry Boehm in mid-1980 is used extensively for software intensive programs, but the principles can be used for enterprises of all types. The USCG Deepwater program is slated to mature in 2022 and it will have to accommodate many upgrades in capabilities until its completion. Spiral development establishes requirements in an iterative process, by partitioning capabilities that can be defined, developed, refined, and matured without causing rippling dependencies among other capabilities. The spiral process encourages in-stream improvement and refinement that allows system developers to upgrade capabilities incrementally until the system fully meets customer expectations. Each spiral can accommodate successive iterations of requirements development and solutions testing, starting from broad aspects and progressing (i.e. spiraling) toward more specific aspects.[58]

The USCG Deepwater program will need constant reevaluation so that changing needs, missions and new technology can be incorporated into the system of systems over the life of the program. The WPC, as an asset of the Deepwater program, will incorporate spiral development that will enable it to be interoperable and interconnected successfully in the network-centric maritime domain in which it will operate.

B. RECOMMENDED ARCHITECTURE FRAMEWORK

The USCG is the world's tenth largest navy and as a small navy it must take its place in the world of network-centric warfare. The Coast Guard is part of the new Department of Homeland Security; however during periods of conflict, such as the Gulf War and prior to that, World War I and II, the service is assigned to the Department of Defense.

In an effort to present the two services as a holistic force, Coast Guard Commandant Adm. Thomas H. Collins and Chief of Naval Operations Adm. Vern Clark signed a National Fleet Policy that stipulates the sea services will maximize the effectiveness of Coast Guard and Navy forces across their maritime and naval missions.

In effect, the WPC's mission includes the ability to be fully interoperable and interconnected in the network-centric maritime domain. This will enable the WPC to receive classified and unclassified data previously unavailable, be aware of its maritime surroundings and to conduct missions in synchronization with Coast Guard and Naval operations.

The Coast Guard and United States Navy are going to synchronize their activities and conduct missions in parallel. The scope of the WPC requires spiral development which requires a framework that has inherent ways to effect interoperability within the DoD net-centric realm, manage risk, and provide a means of cascading development. The DoDAF provides a firm architectural underpinning for all elements of the WPC to be interoperable and is recommended to be used as the architecture framework for the system of systems architecture document for the WPC.

The United States Navy uses the DoDAF to build its programs; this effort is intended to present a common language, foster improved integration of requirements and acquisition processes, support interoperability and affordability. The Coast Guard will

conduct their missions separate from the Navy but with the ability to be interconnected to the Navy and its missions; therefore the DoDAF allows the USCG to develop their programs and platforms with the same integrated architectures as the Navy.

The DoDAF allows for spiral development by the providing products that can be repeatedly iterated through a set of elemental development processes; those products are based on its three views: OV, SV and the TV. The DoDAF can be used to promote interoperability and efficiency through the use of its framework products, which have the capabilities of description - graphical and textually.

C. FLAWS OF ARCHITECTURE FRAMEWORK

The DoDAF is used by the military to develop software-intensive programs to be installed on their platforms. This framework allows the services to produce integrated architectures which provide a logical, structured approach for defining how forces operate, the associated information flow, the relation between that information flow and system capabilities, and the relation between system capabilities and technical standards.[59] The services are able to conduct network-centric warfare in Battle Theater by using the architecture description developed as a result of the use of the DoDAF.

All major documents for use in the development of enterprise architectures have flaws and two major flaws of the DoDAF are its cumbersomeness and lack of business direction.

The DoDAF consist of three major documents which contribute to its unwieldiness. To understand how to apply DoDAF, one needs to read pertinent sections of two of the volumes. In volume I, it is essential that sections 3 (Architecture Uses), 4 (Techniques for Using Architecture Information) and 5 (Architecture Guidelines, Description Process, and Integration) be read and understood. The entire contents of volume II should be read to understand which of the 26 views needs to be applied to one's enterprise development. At a minimum, both AVs, the first three of the OVs, the first six of the SVs and both of the TVs need to be applied to a DoD project using the DoDAF (see Appendix A for product listings). Provided that one is the lead architect of a project, he/she needs to understand most, if not all, of the 26 views that can be applied to an architecture description.

The DoDAF provides for technical guidance within all of its framework products. The AV products capture overarching aspects of architecture that relates to all three of the views and provides pertinent information to the entire architecture. The OV describes the task and activities, operational elements, and information exchanges to accomplish DoD missions. The SV describes a set of graphical and textual products that describes systems and interconnections providing for, or supporting, DoD functions. The TV encompasses the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements.

Within volume I on page 1-2, section 1.3.2, the following statement is made relating to the SV: The SV describes a set of graphical and textual products that describes systems and interconnections providing for, or supporting, DoD functions. DoD functions include both warfighting and business functions. After researching the SV products, it was found that none of them addressed business functions. The DoDAF does not illustrate sound business reasons for the selection of one approach or technology over another.

D.   RECOMMENDED MODIFICATIONS TO FRAMEWORK

Based on research and survey conducted, this thesis recommends that the DoDAF be selected to develop the system of system architecture document for the USCG's WPC. After studying the DoDAF two flaws were recognized: 1) The DoDAF is too cumbersome and 2) it does not illustrate sound business reasons for the selection of one approach or technology over another. This section will recommend modifications to the DoDAF for the aforementioned flaws.

The DoDAF is too cumbersome and to alleviate that, some of the OV and SV products can be combined. The OV-5, OV-6b and OV-6c which describes operational activities, the OV-2 and OV-3 which describes information exchange can be combined and simplified. The SV-1 and SV-2 which identifies nodes and their relationships, the SV-4, SV-5, SV-6, SV-10a, SV-10b and SV-10c which details functions, maps functions and provides details of system data elements, can be combined and simplified. One answer to the survey complained that "One has to page through the various views and try

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to remember them all in order to obtain a coherent picture." This action of combining and simplifying the framework would help to create an over-arching view of the entire architecture description.

To enhance the DoDAF efforts to provide concise business direction, this thesis recommends adding a Motivational View (MV) as developed by D. B. Robi.[60] The MV would include the necessary business, financial, and investment models required to evaluate and prioritize the transition alternatives and modernization plans, thus providing a solid business foundation and rationale of why changes need to be made. The work products are as follows:

- MV-1: Business Case

- MV-2: Investment Decision Model

- MV-3: Risk Analysis Model

- MV-4: Best-Value Low-Risk Model

- MV-5: Balanced Scorecard Model

The business case addresses the rationale for investing the time and resources into making the necessary changes to transform the current as-is to the targeted to be enterprise architecture.

The investment decision model (Figure 7) provides a mechanism to perform an analysis of cost versus benefit to drive the decision-making process.
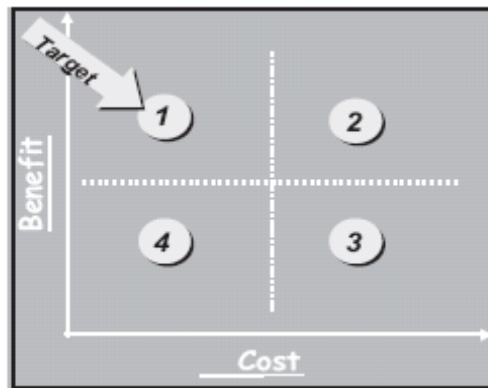

Figure 8.   MV-2:

The risk analysis model (Figure 8) provides a vehicle to identify and analyze risk, which is the probability of occurrence and impact on occurrence.

| Impacted		Probability		
		Low	Medium	High
	Low	Green	Green	Yellow
	Medium	Green	Yellow	Red
	High	Yellow	Red	Red

Figure 9.   MV-3 Risk Analysis Model

The best-value low-risk model provides the next step in selecting the best alternatives by taking a second look at the investment decision model and comparing the best-value candidates on the basis of risk (Figure 9).
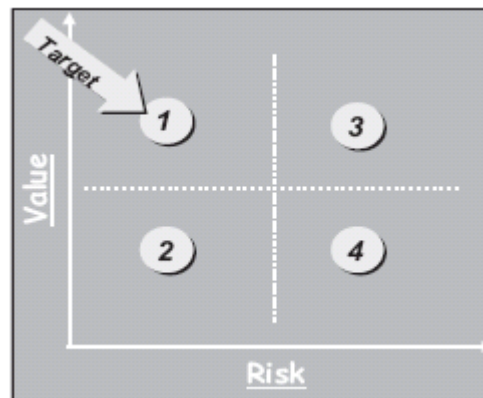
Figure 10.   MV-4 Best-value Low-risk Model

The balanced scorecard model is used to provide a common standard model to manage the business and enterprise architecture, as shown in Figure 11.
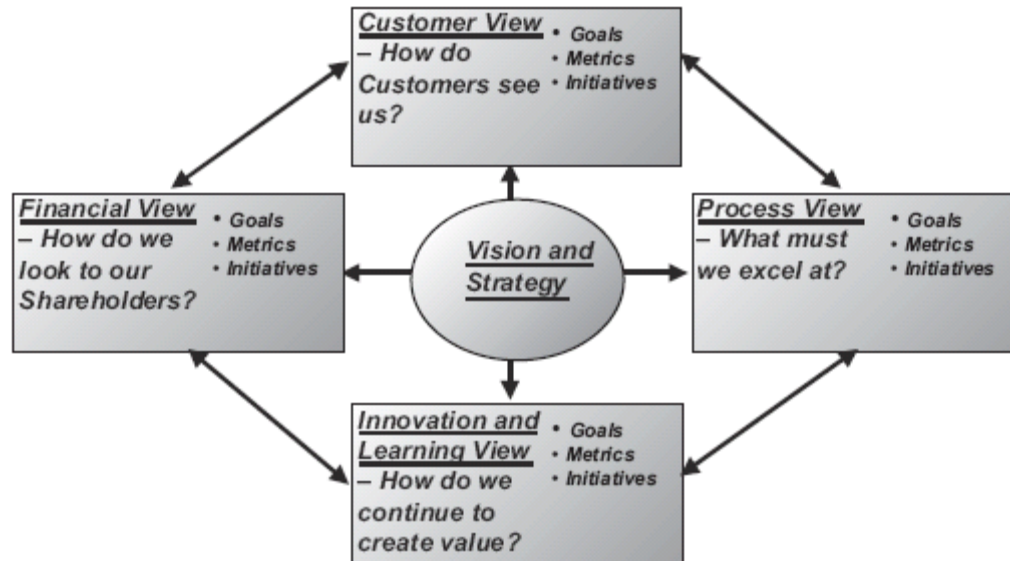
Figure 11.   MV-5: Balanced Scorecard Model

The DoDAF views do not capture the business prospective needed to develop a sound, transitional plan from as-is to to-be as required in today's architectural projects. However, the Motivational Views described seek to capture the missing business perspective, compliment the existing DoDAF views, and provide a complete holistic view of enterprise architecture.[61]

E.   SUMMARY

There are many documents, methodologies and frameworks that can be used to develop enterprise architecture descriptions and they all have inherited flaws within the document themselves. This thesis has identified two flaws within the DoDAF: 1) It is too cumbersome and 2) It lacks business direction.   These flaws are not all-encompassing, but are pointed out to show the inefficiencies that are brought on by providing too much information in one area of the framework and not enough information in other aspects of the framework.

This thesis proposes modifications to the DoDAF that may prove to be helpful in alleviating the cumbersomeness of the document and provide business direction. One area of concern is the proliferation of framework products. There are 3 views: the OV, SV and TV and combined with the AV, the views have 26 framework products between them. It is proposed to combine some of the views that have similar characteristic such

as the OV-5, OV-6b and OV-6c which describe operational activities. These modifications will streamline the process of selecting the correct framework product to suit the enterprise project. To provide business direction, this thesis proposes that a Motivational View be added to the framework. This view would consist of 5 products: 1) The business case, 2) investment decision model, 3) risk analysis model, 4) best-value low-risk model and 5) balanced scorecard model. These modifications will illustrate sound business reasons for selecting one technology or approach over another.

These modifications would be helpful to the lead architect of an enterprise project, by streamlining processes and providing business direction and giving him/her a holistic view of the enterprise project.

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VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The United States Coast Guard has been defending the United States coastline, rescuing people from dangerous situations, and protecting the citizens of the U.S. for over two and a half centuries. Its mission's objectives are as stated:

Maritime Security Missions

> Drug Interdiction

> EEZ & Living Marine Resource Law/Treaty Enforcement

Maritime Safety Missions

> Search and Rescue

> Marine Safety

> Recreational Boating Safety

> International Ice Patrol

Protection of Natural Resources Mission

> Marine Environmental Protection

> Domestic Fisheries Enforcement

> Protected Living Marine Resource Law Enforcement

Maritime Mobility Missions

> Aids to Navigation

> Icebreaking Services

> Bridge Administration

> Waterways/Vessel Traffic Management

National Defense Missions

> General Defense Operations

Maritime Interception Operations

Military Environmental Response Operations

Port Operations, Security, and Defense

Peacetime Military Engagement

Coastal Sea Control Operations

Polar Icebreaking

The Coast Guard has been stretched to capacity to fulfill its missions and the tragic events of September 11, 2001 compounded the strain on the Coast Guard's aging resources by adding additional responsibilities to the agency. It is estimated that the Coast Guard's duties increased by 40% in matters related to national security after 9/11/2001.

In the mid 1990s a commission was formed to study how to remedy the gaps in asset acquisition. Formerly, the Coast Guard replaced ships and aircraft on a one-to-one basis as needed. This approach wasted time, money and resources and did not give the Coast Guard a secure asset foundation. The commission recommended that the Integrated Deepwater System (IDS) be formed to upgrade existing platforms to integrate with naval forces and to acquire new platforms that would perform its duties within a maritime domain. The development of the new platforms would cover maintenance planning, manpower, supply support, technical manuals, training tools, and computer support.

The IDS proposed that three classes of cutters be acquired: 1) The WMSL, 2) the WMSM and 3) the WPC. The large cutters would have soft-kill capabilities and be able to deploy for extended periods while the smaller cutter (WPC) would be used for drug interdiction and law-enforcement duties. Based on mission need, it was thought that the system of system architecture document could be developed using another architecture framework besides the DoDAF that was used to develop the system of systems architecture document for the larger cutters.

This thesis compares the Zachman architecture framework and DoDAF for use as the system of systems architecture framework for the WPC. During the comparison of

the two architecture framework, it was recognized that the Zachman architecture framework is an excellent methodology, excellent thinking tool, and simplistic to use. However, some of the drawbacks to using the Zachman are that it does not provide business direction, does not provide cognitive direction and is primitive. Likewise the DoDAF is comprehensive, highly organized and a great networking document. However, some drawbacks to using DoDAF are that it is too cumbersome, inelastic, and unalterable.

A survey was sent to sixty-seven technical directors, managers, supervisors and architects of Northrop Grumman Ship Systems and Raytheon Corporation. Eighteen individuals responded and their overwhelming choice of architecture framework for use is the DoDAF. And most of them agreed that an architecture framework must be used for the development of large-scale complex enterprises.

Based on the need for the Coast Guard to integrate and be fully interconnected with the United States Navy's C4ISR systems, to follow a step-by-step organizational process, and be comprehensive in scope, this thesis recommends that the DoDAF be chosen as the architecture framework for the WPC's system of systems architecture document.

B.   RECOMMENDATIONS FOR FUTURE RESEARCH

This thesis did not consider the avenue of using multiple frameworks to develop the WPC's system of systems architecture document. One could conceivably use one framework to develop lower level sub-systems and use another framework to develop the overall enterprise. This methodology should be researched for use on other large-scale complex DoD projects.

Another avenue not taken by this thesis is the use of the DoD Enterprise Architecture 2 Business Reference Model in conjunction with the DoDAF for use as a business/technical framework. Further research should be conducted to analyze if the two frameworks can be used together to capture the business activities of enterprise development.

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APPENDIX

Table 1.   Architectural Products [C41SRAF 97]

Table 1:   Architectural Products [C4ISRAF 97]

Applicable View	Framework Product	Framework Product Name	General Description
All Views	AV-1	Overview and Summary Information	Scope, purpose, intended users, environment depicted, analytical findings
	AV-2	Integrated Dictionary	Data repository with definitions of all terms used in all products
Operational	OV-1	High-Level Operational Concept Graphic	High-level graphical/textual description of operational concept
	OV-2	Operational Node Connectivity Description	Operational nodes, operational activities performed at each node, connectivity and information exchange needlines between nodes
	OV-3	Operational Information Exchange Matrix	Information exchanged between nodes and the relevant attributes of that exchange
	OV-4	Organizational Relationships Chart	Organizational, role, or other relationships among organizations
	OV-5	Operational Activity Model	Operational activities and relationships among activities, inputs, and outputs. Overlays can show cost, performing nodes, or other pertinent information.
	OV-6a	Operational Rules Model	One of the three products used to describe the operational activity sequence and timing; identifies business rules that constrain operation
	OV-6b	Operational State Transition Description	One of three products used to describe the operational activity sequence and timing; identifies business process responses to events
	OV-6c	Operational Event-Trace Description	One of three products used to describe the operational activity sequence and timing; traces actions in a scenario or sequence of events and specifies the timing of events
	OV-7	Logical Data Model	Documentation of the data requirements and structural business process rules of the OV.

Table 1:   Architectural Products [C4ISRAF 97] (continued)

Applicable View	Framework Product	Framework Product Name	General Description
Systems	SV-1	Systems Interface Description	Identification of systems and system components and their interconnections, within and between nodes
	SV-2	Systems Communications Description	Physical nodes and their related communications laydowns
	SV-3	Systems-Systems Matrix	Relationships among systems in a given architecture; can be designed to show relationships of interest (e.g., system-type interfaces, planned vs. existing interfaces).
	SV-4	Systems Functionality Description	Functions performed by systems and the information flow among system functions
	SV-5	Operational Activity to Systems Function Traceability Matrix	Mapping of systems back to operational capabilities or of system functions back to operational activities
	SV-6	Systems Data Exchange Matrix	Provides details of systems data being exchanged between systems
	SV-7	Systems Performance Parameters Matrix	Performance characteristics of each system's hardware and software elements, for the appropriate time frame
	SV-8	Systems Evolution Description	Planned incremental steps toward migrating a suite of systems to a more efficient suite, or toward evolving a current system to a future implementation
	SV-9	Systems Technology Forecast	Emerging technologies and software/hardware products that are expected to be available in a given set of time frames, and that will affect future development of the architecture
	SV-10a	Systems Rules Model	One of three products used to describe systems activity sequence and timing—constraints that are imposed on systems functionality due to some aspect of systems design or implementation
	SV-10b	Systems State Transition Description	One of three products used to describe systems activity sequence and timing—responses of a system to events
	SV-10c	Systems Event-Trace Description	One of three products used to describe systems activity sequence and timing—system-specific refinements of critical sequences of events and the timing of these events
	SV-11	Physical Schema	Physical implementation of the Logical Data Model's information (e.g., message formats, file structures, physical schema)

Table 1:   Architectural Products [C4ISRAF 97] (continued)

Applicable View	Framework Product	Framework Product Name	General Description
Technical	TV-1	Technical Standards Profile	Extraction of standards that apply to the given architecture
	TV-2	Technical Standards Forecast	Description of emerging standards that are expected to apply to the given architecture, within an appropriate set of time frames

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